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Four new records of *Caloplaca* (lichenized *Ascomycetes*) from India

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Abstract — Detailed taxonomic descriptions are presented for four species of the lichen genus *Caloplaca*, newly reported from India. *Caloplaca litoricola* (also newly reported from Asia) is a littoral species, recorded only from coastal regions in India, while *C. chalybaea, C. lypera,* and *C. maura* are recorded only from inland areas.

Key words — *Chalybaeae, Chrysophorae, Conversae, Kamczatica, Ochrotropae, Sideritis, Teloschistaceae*

Introduction

Until 2009, numerous floristic or revisionary papers dealing with either the lichen family *Teloschistaceae* Zahlbr. or the genera *Caloplaca* Th. Fr., *Ioplaca* Poelt, and *Xanthoria* (Fr.) Th. Fr. from India were published (Acharius 1810, 1814; Räsänen 1950, 1952; Awasthi 1963, 1965, 1986, 1988, 1991, 2000, 2007; Singh 1964; Poelt 1977; Singh & Awasthi 1978; Singh 1981; Poelt & Hinteregger 1993; Singh & Sinha 1994; Sinha & Singh 2005; Joshi & Upreti 2006, 2007a,b, 2008; Joshi et al. 2008, 2009). Addtionally, Joshi revised the *Teloschistaceae* from India in an unpublished thesis (Joshi 2008), describing 78 teloschistacean species, of which 67 represent *Caloplaca.* In this thesis, he cited *C. chalybaea, C. litoricola, C. lypera,* and *C. maura* as occurring in India. Since these species have not been included in any published accounts of the Indian lichen biota, we provide detailed taxonomic descriptions, chemical and ecological data, and comments for each species to expand the knowledge of lichen diversity in India.

Materials & methods

The study is based on lichen specimens deposited in the herbarium of LWG (including LWG–LWU). Specimens were examined using standard microscopical techniques and were hand-sectioned under Digi-Zoom binocular. All measurements were made on

material mounted in water; lactophenol cotton blue (LCB) was used only as a stain. Spot test reactions were carried out on hand-sections of thalli and apothecia under Nikon Eclipse 400 compound microscope. The K+ purple reaction of the epihymenium should not be confused with K+ red reaction, as the former represents lack of parietin complex in the taxa. Species with K+ red reaction will always have parietin complex. Measurements of ascospores were made at ×400 magnification mounted in water; only free ascospores lying outside the asci were measured. The number of microscopical measurements (n) taken is noted at the end of the pertinent description for each species. Secondary metabolites were identified by TLC as described by White & James (1985) using solvent system C. HCl was used to detect the nature of rock (bubbles indicate calcareous rock).

Taxonomy

Caloplaca chalybaea (Fr.) Müll. Arg., Mém. Soc. Phys. Hist. nat. Genève 16: 388, 1862.

Specimens examined: **INDIA**. **Madhya Pradesh**: Anuppur district, Amarkantak, 10 km before Kabir Chabutra (Attaria), alt. 510 m, on quartz rocks, 22 March 2004, Upreti, Nayaka & Satya 04-002372, 04-002359/B (LWG); Hoshangabad district, Pachmarhi, on way to little fall, alt. ca. 1050 m, on rock, 24 January 1973, S.R. Singh 73.135 (LWG). **Tamil Nadu**: Chennai, Pulboli, LHS, alt. 1030 m, on rock, 25 July 2000, Hariharan & Balaji CS12a (MSSRF).

Thallus crustose, saxicolous, appearing as spotted grayish patch on a dark black hypothallus, areolate to coarsely rimose-areolate, olivaceous gray to brownish-gray to lead gray to pale gray. Cortex paraplectenchymatous. Medulla white. Prothallus black, dendritic.

Apothecia numerous, scattered to ± clustered, immersed in the thallus at first, later on sessile, round, 0.2–0.3 mm in diam.; disc brownish-red to brownish-black to black, flat to subconvex; proper margin thin to moderate, smooth, entire, persistent, concolorous or slightly darker than disc, glossy, in cross-section of indistinct to small oval cells; thalline margin thin, at maturity ± restricted to the base of apothecia, concolorous with the thallus. Epihymenium brownish to golden-brown. Hymenium hyaline, 40–60 µm high. Hypothecium hyaline, of paraplectenchymatous cells, impregnated with crystals, oil globules absent. Amphithecium with algae. Paraphyses simple to furcated, with upper 1–3 cells swollen. Asci 8-spored, spores polarilocular, ellipsoid, (6–)8–14 × 3–6 µm, isthmus 1–3 µm. Pycnidia numerous, 1–3 per areolae, ostiole brownish-black to black, conidia bacilliform, 1–2 × 0.5–0.7 µm. [n = 20 for all measurements.] For further descriptions see Wunder (1974).

Chemistry — Spot test reactions: Thallus K+ yellow, C–. Medulla K–, C–. Apothecial disc K+ purple or K–. Epihymenium K+ faint purple. Secondary metabolites: atranorin.

Ecology and distribution — *Caloplaca chalybaea* was found growing over boulders (quartzite) in tropical regions between 510–1050 m. It was

accompanied by *Caloplaca subsoluta* (Nyl.) Zahlbr. and *C. cinnabarina* (Ach.) Zahlbr.

Wade (1965) and Wunder (1974) reported this species growing over dolomite and calcareous rocks from Central Europe. Later, Fletcher & Laundon (2009) reported this species growing over hard limestone, natural boulders, buildings, and chest tombs from Europe, Macaronesia, Asia, and Africa. Wetmore (1994) reported it from North and Central America. The present study extends its distribution in India

Reference specimen examined: **FRANCE**. **Vaucluse**: Lagarde [inter Rustrel et saint Christol], prope Le Buis, alt. 1000 m.s.m., 23 April 1965, ad saxa calcarea, leg. G. Clauzade, J. Lambinon et A. Vězda 399 (A. Vězda: Lichenes selecti exsiccati).

Remarks — According to Hansen et al. (1987) and Poelt & Hinteregger (1993), *C. chalybaea* belongs to *Chalybaeae* group, comprising species characterized by a crustose to poorly effigurate grayish thallus, brown to black apothecial disc without anthraquinone crystals but with diffused gray-violet pigments, and widely ellipsoid spores with a tendency of reduced septum. Later Wetmore (1994) placed this species in a group of taxa characterized by brown or black-fruited apothecial disc, K–/K+ yellow thallus, and K–/K+ purplish epihymenium. This rather large group includes species representing mostly all ecological groups, e.g., corticolous, lignicolous, and saxicolous (Massalongo 1853; Wetmore 1994). Five other members of this group previously reported from India (Singh & Awasthi 1978; Poelt & Hinteregger 1993; Joshi & Upreti 2007a; Joshi et al. 2009) include three corticolous species — *C. atrosanguinea* (G. Merr.) I.M. Lamb, *C. pollinii* (A. Massal.) Jatta, *C. rinodinopsis* Poelt & Hinter. — and two saxicolous species — *C. transcaspica* (Nyl.) Zahlbr., *C. variabilis* (Pers.) Müll. Arg.

Caloplaca chalybaea is characterized by a crustose areolate to coarsely rimose-areolate grayish thallus with a dendritic black prothallus, numerous small apothecia, a brownish-red to blackish apothecial disc with a concolorous proper margin, and numerous pycnidia with brownish-black to black ostioles. Superficially it resembles *Aspicilia* in habit but is easily distinguished by the polarilocular spores and K+ purple epihymenium. It is close to *C. atroflava* (Turner) Mong., which differs from it in having a dark gray to black, cracked areolate thallus with a brownish-orange apothecial disc lacking a thalline margin and broadly ellipsoid spores. Another related species, *C. concilians* (Nyl.) H. Olivier, is differentiated by bigger apothecia, branched paraphyses, and lack of dendritic prothallus.

Caloplaca litoricola Brodo, Bryologist 87: 98, 1984.

Specimen examined: **INDIA**. **Andhra Pradesh**: Vishakhapatnam, along sea coast, on rock, 07 March 1986, D.D. Awasthi, G. Awasthi, R. Mathur & P. Srivastava 86.272 (LWG-LWU).

Thallus crustose, saxicolous, thin, continuous or areolate, whitish-gray. Cortex cellular and thin. Medulla white. Prothallus absent.

Apothecia numerous, scattered, sessile, round to angular owing to pressure, 0.2–0.6(–0.9) mm in diam.; disc orange-yellow to dark orange, flat to convex; proper margin thick, smooth to wavy, entire, persistent, raised above the level of the disc, black, glossy, in cross-section of radiating elongated hyphal cells, outer surface aeruginose pigmented; thalline margin absent. Epihymenium golden-brown. Hymenium hyaline, 70–90 µm high. Hypothecium hyaline or pale brown, of isodiametric cells, oil globules present. Amphithecium without algal cells. Paraphyses simple, rarely branched, without swollen tips or with 1–3 slightly swollen cells, upper portion covered by epipsamma. Asci 8-spored, spores polarilocular, oval to ellipsoid, 11–16 × 6–9(–10) µm, isthmus 5–6 µm. Pycnidia immersed, ostiole black, conidia 2.5–3.2 × 1–1.5 µm. [n = 10 for all measurements.]For further descriptions see Brodo (1984).

Chemistry — Spot test reactions: Thallus and medulla K–, C–. Apothecial disc and epihymenium K+ red, margin K– (remaining aeruginose). Secondary metabolites: parietin.

Ecology and distribution — *Caloplaca litoricola* was found growing on siliceous rocks along the shoreline of Vishakhapatnam district, Andhra Pradesh.

Benton et al. (1977) first reported this species (as *Caloplaca* sp.) from Bamfield Marine Station, Vancouver Island (North America). Brodo (1984) cited *C. litoricola* from the Queen Charlotte Islands and Long Beach (Ucluelet) on Vancouver Island's west coast, and Arup (1995ab) and Wetmore (1996) reported it growing over non-calcareous maritime rocks from Washington to Alaska. Our report represents the first for Asia, where it is thus far known only from India's east coast.

Reference specimen examined **CANADA. British Columbia**: Queen Charlotte Islands: Graham Island, Tow Hill, alt. 54°04′N, 131°47′W, on shoreline rock, 16 June 1967, I.M. Brodo & M.J. Shchepanek 9905 (Isotype–CANL).

Remarks — Wetmore (1996) placed this *C. litoricola* in the *Sideritis* group, which consists chiefly of saxicolous species with gray, whitish, or brown thalli that lack anthraquinones and red or orange anthraquinone-containing apothecia. Søchting (2004), however, referred it to the *Kamczatica* group, which comprises both corticolous and saxicolous species with grayish thalli lacking anthraquinones and black-margined yellowish orange anthraquinone-containing apothecial discs, but which differs from the *Sideritis* group in lacking algal cells in amphithecium. Recently Wetmore (2007) also refers the species to the *Kamczatica* group. Poelt & Wunder (1967) earlier considered the presence or absence of algae in amphithecium a variable character. Molecular analysis may help settle this taxonomic problem in the future.

In India, this group is represented by only two species, *C. litoricola* and *C. tropica* Y. Joshi & Upreti. Joshi & Upreti (2007a) initially described *C. tropica* under *Sideritis* group, but later (Joshi 2008) placed it along with *C. litoricola* under *Kamczatica* group.

Caloplaca litoricola is characterized by whitish-gray continuous or areolate thallus, orange-yellow to dark orange apothecia with black proper margins, proper exciple of radiating elongated hyphal cells, oval to ellipsoid 11–16 × 6–9 µm spores, and littoral distribution. It is close to *Caloplaca tropica*, which differs in having indistinct thallus, narrowly ellipsoid spores (9–12 × 1.5–2 µm), and a distribution restricted to inland localities of central India.

***Caloplaca lypera* Poelt & Hinter., Biblioth. Lichenol. 50: 159, 1993.**

Specimens examined: **INDIA**. **Uttarakhand**: Bageshwar district, Phurkia Dakbunglow, alt. 3450 m, on stones, 10 June 1970, D.D. Awasthi, 7676 (LWG–AWAS); Pithoragarh district, Munsiyari, alt. 2200 m, on rocks, 17 November 2006, Y. Joshi & R. Bajpai 06-006276, 06-007008 (LWG); alt. 2500 m, on rocks, 16 November 2006, Y. Joshi & R. Bajpai 06-006234 (LWG); Khaliya top, alt. 2700–3000 m, on rocks, 17 November 2006, Y. Joshi & R. Bajpai 06-006273 (LWG).

Thallus crustose, saxicolous, determinate, irregular to ± orbicular, zonate, cracked areolate, gray to ash-gray to ochraceous-gray, glossy. Cortex paraplectenchymatous. Medulla yellow. Prothallus generally absent but black when present.

Apothecia numerous, scattered to clustered, restricted to the central parts of the thallus, sessile, initially round, later on angular owing to pressure from neighboring apothecia, 0.2–0.7(–1.2) mm in diam.; disc reddish-brown to mostly olivaceous black, flat; proper margin thin, entire, persistent, smooth to flexuose, dirty brownish-red, paler than disc, in cross-section of slightly elongated cells to ± paraplectenchymatous, broadly fan-shaped; thalline margin thick, entire, persistent, smooth to flexuose, yellowish to muddy orange or rarely thallus-coloured. Epihymenium yellowish-orange to brownish-orange, with fine granular epipsamma. Hymenium hyaline, ca. 100 µm high. Hypothecium hyaline, of indistinct cells, with oil globules. Amphithecium with algae. Paraphyses thin, simple, rarely branched, with clavate apical cells surrounded by epipsamma. Asci 8-spored, spores polarilocular, ellipsoid to broadly ellipsoid, 15–17 × 7–9 µm, isthmus 4.5–6 µm. Pycnidia present, numerous, ostiole brown to brownish-red, conidia bacilliform, 3–4 × 1–1.5 µm. [n = 20 for all measurements.] For further descriptions see Poelt & Hinteregger (1993).

Chemistry — Spot test reactions: Thallus K– to K+ faint red in some regions, C–. Medulla, apothecial disc and epihymenium K+ red, C–. Secondary metabolites: parietin.

Ecology and distribution — *Caloplaca lypera* is found growing along roadside on the vertical faces of rocks between elevations of 2200–3450 m in

temperate regions of Central Himalaya. Poelt & Hinteregger (1993) reported this species growing over hard, lime free siliceous rocks at 2700 m in the Langtang area of Nepal. The present study extends its distribution in India.

Reference specimen examined: **NEPAL. Langtang Area**: On way Khangjung to Sangsa (E of Khangjung), towards Pang Sang Lekh, pastures, rocks, open woods, alt. 2700 m, on rock, 28 August 1986, J. Poelt 000279609 (Holotype–GZU).

Remarks —Poelt & Hinteregger (1993) place *C. lypera* in the *Chrysophorae* group, characterized by crustose to lobate, gray to olive-brown thalli with partially or completely brownish-black apothecia and widely ellipsoid spores. Members of this group colonize lime-poor rocks. So far it is the only known representative of this group from India. The *Ochrotropae* group (Poelt & Hinteregger 1993) is similar enough to the *Chrysophorae* group, that molecular analyses are needed to settle the taxonomy.

Caloplaca lypera is mainly characterized by an irregularly cracked areolate, grayish or ochraceous coloured thallus with a yellow medulla and a reddish-brown to olivaceous-black apothecial disc surrounded by yellow thalline margin. Outwardly it resembles *Lecanora luteomarginata* Nayaka et al., but differs in having yellow medulla and polarilocular spores.

Caloplaca maura Poelt & Hinter., Biblioth. Lichenol. 50: 161, 1993.

Specimen examined: **INDIA. Sikkim**: North Sikkim, Giagaon, above Thanngu, alt. 4600 m, on detritus, 13 August 2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004004 (LWG).

Thallus crustose, muscicolous/terricolous, often coalescing with other thalli to cover large areas, indistinct to squamulose, squamules small, gray. Cortex paraplectenchymatous. Medulla white. Prothallus absent.

Apothecia numerous, scattered to clustered, sessile to constricted at base, round, 0.2–0.3(–0.5) mm in diam.; disc brownish-black to black, sometimes covered with yellowish-brown to yellowish-orange granules (epipsamma), flat; proper margin thick, smooth, persistent, entire, raised above the level of disc to ± flush, black, in cross-section of elongated radiating cells; thalline margin ± present, thin, smooth to crenulate, concolorous to thallus. Epihymenium golden to golden-brown. Hymenium hyaline, 70–100 µm high. Hypothecium hyaline, thin, of indistinct cells, without oil globules. Amphithecium with algae, algal layer continuous below exciple, outer surface aeruginose pigmented. Paraphyses in upper region are repeatedly branched, end cells club-shaped to capitate. Asci 8-spored, spores polarilocular, broadly ellipsoid, 12–18 × 6–10 µm, isthmus 3–5 µm. Pycnidia not seen. [n = 10 for all measurements.] For further descriptions see Poelt & Hinteregger (1993).

Chemistry — Spot test reactions: Thallus and medulla K–, C–. Apothecial disc and epihymenium K+ red, C–. Secondary metabolites: parietin.

Ecology and distribution — The present study extends its distribution in India where it is found growing on detritus in alpine regions at 4600 m in the eastern Himalaya. Poelt & Hinteregger (1993) reported this species growing over wood of *Kobresia pygmaea* in the Khumbu region of Nepal.

Remarks —Poelt & Hinteregger (1993) place *C. maura* in the *Conversae* group, characterized by crustose to areolate, ± dark gray thalli and small, blackish or black apothecial discs with concolorous margins. Most species in this group prefer rocky habitats, but some grow over bark, moss, and detritus. *Caloplaca rinodinopsis,* a corticolous species, is the other known representative of this group from India.

Caloplaca maura is characterized by an indistinct to squamulose gray thallus, apothecia with brownish-red to black discs ± covered by yellowish granules. A subtemperate distribution, orange to orange-brown apothecial disc, and non-thalline margin separate the closely related muscicolous *C. cerina* var. *muscorum* (A. Massal.) Jatta from *C. maura.*

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